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(71) Applicant *(for all designated States except US)*: EMBRACING SOUND EXPERIENCE AB [SE/SE]; Box 15108, S-750 15 Uppsala (SE).

(72) Inventors; and
(75) Inventors/Applicants *(for US only)*: HEED, Christer [SE/SE]; Terapivägen 4C, S-141 55 Huddinge (SE). GUNNARSSON, Fredrik [SE/SE]; Visättravägen 43, S-141 50 Huddinge (SE).

(74) Agent: EHRNER & DELMAR PATENTBYRÅ AB; Box 103 16, Gumshornsgatan 7, S-100 55 Stockholm (SE).

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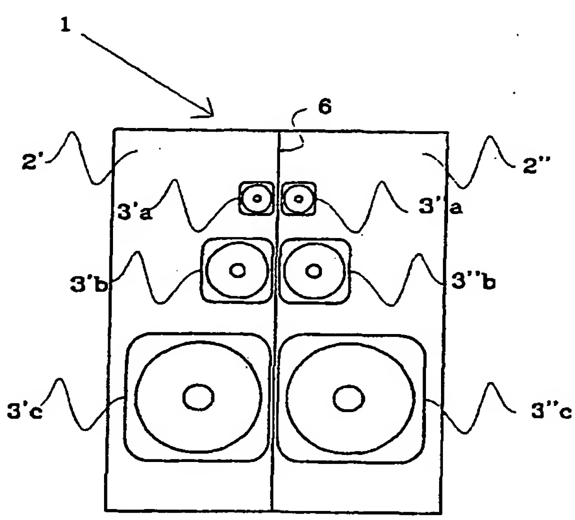
(54) Title: TWO METHODS AND TWO DEVICES FOR PROCESSING AN INPUT AUDIO STEREO SIGNAL, AND AN AUDIO STEREO SIGNAL REPRODUCTION SYSTEM




(57) Abstract: The present invention relates to methods and devices for processing one or the other of two types of common input audio stereo signals so that the output signals will reproduce normally wide stereo sound from an audio stereo reproduction system comprising a pair of identical loudspeakers positioned adjacent or close to each other. Thus, the invention relates partly to a method and a device for producing that specific pair of left and right output signals from one kind (M + S) of input signals, and partly to a method and a device for producing a similar type of left and right output signals from another kind (L + R) of input signals. Finally, the invention relates to an audio stereo signal reproduction system comprising a pair of identical loudspeakers positioned adjacent or close to each other and intended for reproduction of normally wide stereo sound from one (M + S) of said kinds of input signals.

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Two methods and two devices for processing an input audio stereo signal, and an audio stereo signal reproduction system.

## FIELD OF THE INVENTION

The present invention relates in general to a method and a device for processing and reproducing an audio stereo signal and to a corresponding audio stereo signal reproduction system. More particularly, the present invention relates to an audio stereo signal reproduction system, and to a method of processing an audio stereo signal for retaining the apparent stereo image emitted from such a reproduction system.

## BACKGROUND OF THE INVENTION

A large number of methods and systems exist intended for faithful reproduction of the sound experienced by a listener at the recording position. The only one of these that is able to truly reproduce the stereo effect, i.e. the impression of the different sound sources originating from different spatial positions, is using stereo headphones. Listening to a recorded stereo sound using headphones, the listener may perceive a stereo image identical to the image that would have been perceived at the recording site. This method is however not suitable for reproduction of stereo sound to an audience consisting of more than one listener. To overcome this drawback, audio stereo reproduction systems comprising two, or more, loudspeakers are used for reproducing stereo sound to an audience. Most of these systems are based on a pair of widely spaced loudspeakers, and true reproduction of the stereo effect, both in terms of relative intensity between the sound perceived by the listeners' two ears and the time difference between these, can be perceived only at a single position in relation to the loudspeakers. This implies that only one listener in an audience can experience a truly correct stereo

effect. All other members of the audience will therefore experience a distorted stereo effect. Different ways to widen the area over which the perceived stereo impression is nearly correct have been attempted, with varying degrees of success.

Physically separating the two loudspeakers a distance large enough for enabling reproduction of the stereo impression to at least one listener is generally impractical, and in certain cases impossible. Examples of such cases are single unit stereo radio or CD players with integral loudspeakers, or reproduction of stereo sound to several listeners in cars or small rooms. Adjusting the relative intensities of the side and the mid signals reproduced by an AB stereo system, to increase the perceived stereo width might improve the impression of stereo width, but might also distort the stereo image, and it is not recommended to shift the ratio between the two signals by more than 3dB. Other methods of improving the perceived stereo effect from narrowly separated loudspeakers have also been suggested, but have proven to give limited effect.

## SUMMARY OF THE INVENTION

It is an object of the present invention to provide a method and a device for processing an audio stereo signal, such that it can be reproduced with a high degree of fidelity in the perceived stereo effect over a larger area than possible with previous methods.

It is another object of the present invention to provide a method and a device for processing an audio stereo signal, such that it can be reproduced with a high degree of fidelity in the perceived stereo image, using a pair of loudspeakers being situated in immediate vicinity of each other.

According to the present invention, the method and the device produces a left and a right output signal from an input audio stereo signal pair. The left output signal is equivalent to the sum of the mid input signal (M) attenuated by a factor $\alpha$ and the side input signal (S), and the right output signal is equivalent to the sum of the mid input signal (M) attenuated by the factor $\alpha$ and the side signal (S) phase shifted 180°. The left and the right output signal form an output audio stereo signal. Finally, the output stereo signal is directed to an audio stereo signal reproduction system, comprising a pair of loudspeaker units located in close proximity to each other.

It is yet another object of the present invention to provide a loudspeaker system, comprising at least one pair of identical loudspeaker elements, suited for reproducing an audio stereo signal processed according to the presented method. A pair of two identical loudspeaker elements does here mean that the elements have essentially identical transmission functions, i.e. they respond in an essentially identical way to an electrical input signal in terms of the sound waves emitted from the elements.

According to the present invention, the system comprises at least one pair of identical loudspeaker elements positioned on a baffle with separated resonating volumes that acoustically isolates the two elements from each other. The loudspeaker elements of said pair of loudspeaker elements are positioned symmetrically on opposite sides of an imaginary dividing plane. The loudspeaker elements of said pair of elements are positioned with a distance between the centres of the elements of less than one quarter of the shortest wavelength emitted by the elements, or, if the shortest wavelength emitted by the

elements is less than 68 cm, less than 17 cm. Preferably, the elements are positioned adjacent to each other.

According to another aspect of the invention, the system comprises more than one such pair of loudspeaker elements, where each pair share a common dividing plane.

According to yet another aspect of the invention, the system may also comprise a processing device of the kind described above.

BRIEF DESCRIPTION OF THE DRAWINGS

Fig. 1 is a block diagram illustrating the processing method according to the invention for M-S signals;

Fig. 2 is a block diagram illustrating the processing method according to the invention for L-R signals;

Fig. 3 is a front view of a first embodiment of a loudspeaker system; and

Fig. 4 is a partial cross sectional top view of the loudspeaker system shown in Fig. 3.

Fig. 5 is a front view of a second embodiment of a loudspeaker system.

Fig. 6 is a partial cross sectional top view of the loudspeaker system shown in Fig. 5.

Fig. 7 is a partial cross sectional side view of the loudspeaker system shown in Fig. 5.

DESCRIPTION OF A PREFERRED EMBODIMENT

Fig. 1 illustrates the method of processing an audio stereo signal, and thus also the function of a device, according to the present invention for M-S input signals. The input audio stereo signal comprises a mid signal M, and a side signal S, corresponding to the difference between the left, L, and right, R, input stereo signals, and the sum of the left, L, and right, R, input stereo signals, respectively. According to the method, the output stereo signal $L_{OUT}$, which is to be sent to a left sound reproducing unit 2' is the sum of the side signal, S, and the mid signal M multiplied by a attenuating factor $\alpha$, while the output stereo signal $R_{OUT}$, which is to be sent to a right sound reproducing unit 2'' is the sum of the inverted side signal, S, and the mid signal M multiplied by a attenuating factor $\alpha$. This can be expressed mathematically as

$$\begin{bmatrix} L_{OUT} \\ R_{OUT} \end{bmatrix} = \begin{bmatrix} \alpha & 1 \\ \alpha & -1 \end{bmatrix} \begin{bmatrix} M \\ S \end{bmatrix}.$$

Inverting the side signal is equivalent to negating it or phase shifting it 180 degrees.

The mid signal M is attenuated a factor $\alpha$, which, assuming the recording system as well as previous and subsequent stereo signal processing and stereo reproducing systems are optimal, would typically be -6 dB to -9dB. The attenuated mid signal is then added to the S and -S signals, respectively, and the resulting pair of signals are fed to a pair of audio signal reproduction elements. Reproducing the resulting signals by an ordinary audio reproduction system with widely separated loudspeaker elements does however not give a satisfactory result, and only by using the audio stereo signal reproduction

system according to the present invention, a stereo effect is reproduced with fidelity.

In a general case the attenuation factor $\alpha$ is adapted to optimise the stereo effect perceived by the listener, and is allowed to vary in an interval from -3 dB to -10 dB. It has been found that the optimum value is dependent upon the angle of distribution of the sound emitted from the loudspeaker elements. For elements with a narrow distribution angle, the optimum value is approximately -6dB, while for elements with a wide distribution angle, the optimum value is approximately -9 dB.

An output stereo signal $L_{OUT}$, $R_{OUT}$, may be multiplied by a normalisation factor, which compensates for the slight change in signal power but, generally, attenuating or amplifying an output signal is known in the art.

Fig. 2 illustrates the same method of processing an audio stereo signal according to the present invention as above, but for L-R input signals. The input audio stereo signal comprises a left, L, and a right, R, stereo signal, corresponding to half the sum of the mid, M, and the side S stereo signals and half the difference between the mid signal M, and the side signal S, respectively. According to the method, the left output stereo signal, $L_{OUT}$, is the sum of the left stereo signal, L, multiplied by a factor of $1+\alpha$, and the right stereo signal, R, multiplied by a factor of $\alpha-1$, while the right output stereo signal $R_{OUT}$, is the sum of the left stereo signal, L, multiplied by a factor of $\alpha-1$, and the right stereo signal, R, multiplied by a factor of $1+\alpha$. This can be expressed mathematically as

$$\begin{bmatrix} L_{OUT} \\ R_{OUT} \end{bmatrix} = \begin{bmatrix} 1+\alpha & \alpha-1 \\ \alpha-1 & 1+\alpha \end{bmatrix} \begin{bmatrix} L \\ R \end{bmatrix}.$$

The two seemingly different methods described above are obviously identical in terms of the resulting output, as the R and L signals can be found by a linear transformation of the M and S signals. Mathematically, this is shown by the transformation

$$\begin{bmatrix} L_{OUT} \\ R_{OUT} \end{bmatrix} = \begin{bmatrix} \alpha & 1 \\ \alpha & -1 \end{bmatrix} \begin{bmatrix} M \\ S \end{bmatrix} = \begin{bmatrix} \alpha & 1 \\ \alpha & -1 \end{bmatrix} \begin{bmatrix} 1 & 1 \\ 1 & -1 \end{bmatrix} \begin{bmatrix} L \\ R \end{bmatrix} = \begin{bmatrix} 1+\alpha & \alpha-1 \\ \alpha-1 & 1+\alpha \end{bmatrix} \begin{bmatrix} L \\ R \end{bmatrix}.$$

Generally, therefore, the method could equivalently be used for any input terms which can be described as a linear transformation of the R and L signals or the M and S signals, but as a matter of convenience, the method is exemplified using the M and S, and the R and L pictures, respectively. The method should therefore be interpreted as a method having an output, which is equivalent to $S+\alpha M$ and $-S+\alpha M$, whether the input signals actually comprises an M and an S signal, or if these signals can be derived from the input signals, such as is the case if the input signals comprises the L and R signals, or any other signals which can be linearly transformed into the M and S signals.

The method may produce the M and S signals during an intermediate step in the process, but it does not imply that these have to be produced.

Fig. 3 shows a preferred embodiment of the audio stereo signal reproduction system according to the present invention. The sound reproduction system 1 comprises two sound reproducing units 2' and 2'', each of which comprises one or several, in this case three, loudspeaker elements 3'a, 3'b, 3'c and 3''a,

3''b, 3''c. As shown, the sound reproduction system 1 could include one common enclosure with a barrier 6 between the two sound reproducing units 2' and 2'', acoustically isolating the resonator volumes of the two units from each other. The term acoustical isolation does here imply that no, or little, sound is transferred from one resonator volume to the other. Alternatively it could consist of two separate units, placed in immediate vicinity of each other, or even being attached to each other. In each instance, each pair of corresponding loudspeaker elements in each of the sound reproducing units should be positioned symmetrically with respect to the separating plane, which in the illustrated embodiment would be defined by the barrier 6, in order to achieve a uniform sound pattern being emitted by each pair of loudspeaker elements 3'a, 3''a, etc. In addition, each loudspeaker element 3'a, 3''a etc. of each pair should be positioned as close to the other as practically possible in order to get minimal coloration caused by lobing in the resultant emitted sound pattern due to interference between the loudspeaker elements. This is achieved when the distance between the loudspeaker elements is smaller than one quarter of the wavelength of the sound being emitted. Achieving this implies that higher frequency loudspeaker elements should be put closer to each other than lower frequency loudspeaker elements.

For sound reproduction systems employing low (first or second) order filters for separating out the parts of the frequency intervals to be reproduced by the mid and high frequency loudspeaker elements, respectively, a comparatively large frequency interval remains which is partially reproduced by both the mid and high frequency loudspeaker elements. This effect will distort the fidelity of the stereo reproduction, and in such a case, it may me preferred to position the mid

and high frequency loudspeaker elements in line with each other horizontally. To compensate for the high frequency loudspeaker elements in this case not being positioned as close to each other as possible, the mid signal attenuation factor $\alpha$ is preferably frequency dependent, $\alpha(f)$, where f is the frequency this also implies to when the speakers physically cannot be placed closer to each other than the distance of the wavelengths emitted by the elements.

In fig. 4 a plate element 4 positioned between the sound reproducing units 2′ and 2′′ is more clearly illustrated. This optional element serves the purpose of enhancing the perceived stereo effect for the mid to high frequency part of the audio spectrum. The plate element 4 is positioned symmetrically with respect to the sound reproducing units and extends essentially orthogonally from the front surface of the sound reproducing units. Its shape and extension from the front surface are adapted to the acoustical properties of the environment, in which the audio stereo signal reproduction system is to be used, and by the properties of the loudspeaker elements 3. Optimally, it extends from the front surface of the loudspeaker element a distance equivalent to half the distance between the centres of the elements in one pair of elements. The acoustical properties of the plate element should be neutral but may be constructed in any type of material that avoids that the sound waves emitted from the two elements in one pair of elements mix with each other until the sound waves have propagated a distance equal to the extent of the plate element 4. It may be retractable and extendable in order to optimise the performance of the system when the acoustical properties of the surroundings are varying.

Fig. 5 shows a second embodiment of an audio stereo sound reproducing system according to the invention, which cannot easily be divided into a left and a right unit. The sound reproducing system 1 comprises five loudspeaker elements 3'a, 3''a, 3'b, 3''b, and 3c. Loudspeaker elements 3'a and 3''a constitute one loudspeaker pair, and loudspeaker elements 3'b and 3''b, constitute a second loudspeaker pair. The two elements in a pair of loudspeakers are identical. The distance between the centres of the elements is less than one quarter of the shortest wavelength emitted by the elements, or, if the shortest wavelength emitted by the elements is less than 68 cm, at least no longer than 17 cm. The loudspeaker elements in a pair are symmetrically positioned on opposite sides of an imaginary dividing plane (not shown). The two pairs constituted by elements 3'a, 3''a, and 3'b, 3''b, respectively, share a common dividing plane. Loudspeaker 3c is not a member of a loudspeaker element pair of this kind.

Fig. 6 shows the embodiment in fig. 5 from above, and fig 7 shows it from the side. As clearly seen in these views, the two element pairs 3'a, 3''a, and 3'b, 3''b and the single element 3c are offset from each other and are positioned at different heights from the rear surface. Even so, the two pairs share a common dividing plane. Each pair is provided with a plate element 4, while the single loudspeaker 3c element is not. The two left elements in each pair 3'a and 3'b are acoustically isolated from the corresponding right elements 3''a and 3''b. The resonance volume for the single element is not divided into a right and a left side, and this resonance volume is acoustically isolated from the other resonance volumes.

The input audio stereo signal sent to a pair of loudspeaker elements, such as the pair comprising elements 3'a, 3''a, or the pair comprising elements 3'b, 3''b, is processed according to the method disclosed here. The processing may be different between two pairs, in terms of the value of the attenuation factor $\alpha$, or its optional frequency dependence, $\alpha(f)$.

Inasmuch as the present invention is subject to variations, modifications and changes in detail, some of which have been stated herein, it is intended that all matter described throughout this entire specification or shown in the accompanying drawings be interpreted as illustrative and not in a limiting sense.

CLAIMS

1. A method of processing an input audio stereo signal comprising two input signals from which a mid input signal (M) and a side input signal (S) can be derived, for reproduction of a processed stereo signal in an audio stereo reproduction system comprising at least one pair of identical loudspeaker elements being acoustically isolated from each other located within less than one quarter of the shortest wavelength emitted by the elements, or, if the shortest wavelength emitted by the elements is less than 68 cm, less than 17 cm, comprising the steps of:

- producing a left output signal for transmission to a left loudspeaker in said pair, which is equivalent to the sum of the mid input signal (M) attenuated by a factor $\alpha$ and the side input signal (S),

- producing a right output signal for transmission to a right loudspeaker in said pair, which is equivalent to the sum of the mid input signal (M) attenuated by the factor $\alpha$ and the side signal (S) phase shifted 180°.

2. The method according to claim 1, **characterised in** that it comprises the steps of:

- producing a left output signal, which is the sum of the mid input signal (M) attenuated by the factor $\alpha$ and the side input signal (S),

- producing a right output signal, which is the sum of the mid input signal (M) attenuated by the

factor α and the side signal (S) phase shifted 180°.

3. The method according to claim 1, **characterised in** that it comprises the steps of:

- producing a left output signal, which is the sum of the left input signal (L) multiplied by a factor α+1 and the right input signal (R) multiplied by a factor α−1,

- producing a right output signal, which is the sum of the left input signal (L) multiplied by the factor α−1 and the right input signal (R) multiplied by the factor α+1.

4. The method according to any one of claims 1 - 3, **characterised in** that the attenuation factor α is in the range - 3 dB to −10 dB.

5. The method according to any one of claims 1 - 3, **characterised in** that the attenuation factor α is in the range −5 dB to −10 dB.

6. The method according to any one of claims 1 - 3, **characterised in** that the attenuation factor α is in the range −6 dB to −9 dB.

7. The method according to any one of claims 1 - 6, **characterised in** that the attenuation factor α is frequency dependent.

8. The method according to any one of claims 1 - 7, **characterised in** that more than one pair of left and right output signals are produced, for reproduction in corresponding pairs of loudspeaker elements.

9. A device for processing an input audio stereo signal comprising two input signals from which a mid input signal (M) and a side input signal (S) can be derived, for reproduction of a processed stereo signal in an audio stereo reproduction system comprising at least one pair of identical loudspeaker elements being acoustically isolated from each other located within less than one quarter of the shortest wavelength emitted by the elements, or, if the shortest wavelength emitted by the elements is less than 68 cm, less than 17 cm, **characterised in** that it:

- produces a left output signal for transmission to a left loudspeaker in said pair, which is equivalent to the sum of the mid input signal (M) attenuated by a factor $\alpha$ and the side input signal (S),

- produces a right output signal for transmission to a right loudspeaker in said pair, which is equivalent to the sum of the mid input signal (M) attenuated by the factor $\alpha$ and the side signal (S) phase shifted 180°.

10. The device according to claim 9, **characterised in** that it:

- produces a left output signal, which is the sum of the mid input signal (M) attenuated by the factor $\alpha$ and the side input signal (S),

- produces a right output signal, which is the sum of the mid input signal (M) attenuated by the factor $\alpha$ and the side signal (S) phase shifted 180°.

11. The device according to claim 9, **characterised in** that it:

- produces a left output signal, which is the sum of the left input signal (L) multiplied by a factor $\alpha+1$ and the right input signal (R) multiplied by a factor $\alpha-1$,

- produces a right output signal, which is the sum of the left input signal (L) multiplied by the factor $\alpha-1$ and the right input signal (R) multiplied by the factor $\alpha+1$.

12. The device according to any one of claims 9 - 11, **characterised in** that the attenuation factor $\alpha$ is in the range - 3 dB to -10 dB.

13. The device according to any one of claims 9 - 11, **characterised in** that the attenuation factor $\alpha$ is in the range -5 dB to -10 dB.

14. The device according to any one of claims 9 - 11, **characterised in** that the attenuation factor $\alpha$ is in the range -6 dB to -9 dB.

15. The device according to any one of claims 9 - 14, **characterised in** that the attenuation factor $\alpha$ is frequency dependent.

16. An audio stereo signal reproduction system, comprising at least one pair of loudspeaker elements (3'a, 3''a; 3'b, 3''b) being acoustically isolated from each other, the elements in said pair being identical to each other and symmetrically positioned on opposite sides of a dividing plane, **characterised** in that

- the loudspeaker elements in said pair of elements are positioned with a distance between the centres of the elements of less than one quarter of the shortest wavelength emitted by the elements, or, if the shortest wavelength emitted by the elements is less than 68 cm, less than 17 cm,

- the left loudspeaker element is arranged to reproduce a signal, which is equivalent to the sum of a mid input signal (M) attenuated by a factor $\alpha$ and a side input signal (S),

- the right loudspeaker element is arranged to reproduce a signal, which is equivalent to the sum of a mid input signal (M) attenuated by a factor $\alpha$ and a side signal (S) phase shifted 180°.

17. An audio stereo signal reproduction system according to claim 16, **characterised in** that the loudspeaker element of said pair of loudspeaker elements are mounted adjacent to each other.

18. An audio stereo signal reproduction system according to claim 16 or 17, **characterised in** that said audio stereo signal reproduction system comprises more than one of said pairs of elements.

19. An audio stereo signal reproduction system according to claim 18, **characterised in** that said pairs share a common dividing plane.

20. An audio stereo signal reproduction system according to claim 19, **characterised in** that said pairs are arranged in one integral enclosure.

21. An audio stereo signal reproduction system according to any one of claims 16 - 20, **characterised in** that a plate element (4) is disposed centrally between at least one of said pair(s) of loudspeaker elements, extending from the front surface of said pair of loudspeaker elements.

22. An audio stereo signal reproduction system according to claim 21, **characterised in** that said plate element is fixed.

23. An audio stereo signal reproduction system according to claim 21, **characterised in** that said plate element is retractable.

24. An audio stereo signal reproduction system according to claim 21 - 23, **characterised in** that said plate element at least in its extended state extends a distance from the front surface of said pair of loudspeaker elements equivalent to half the distance between the centres of each loudspeaker element in said pair.

25. An audio stereo signal reproduction system according to any one of claims 16 - 24, **characterised in** that the attenuation factor $\alpha$ is in the range - 3 dB to -10 dB.

26. An audio stereo signal reproduction system according to any one of claims 16 - 24, **characterised in** that the attenuation factor $\alpha$ is in the range -5 dB to -10 dB.

27. An audio stereo signal reproduction system according to any one of claims 16 - 24, **characterised in** that the attenuation factor $\alpha$ is in the range -6 dB to -9 dB.

28. An audio stereo signal reproduction system according to any one of claims 16 - 27, **characterised in** that it comprises a device for processing an input audio stereo signal, which

- produces a left output signal for transmission to the left loudspeaker in said pair, which is equivalent to the sum of the mid input signal (M) attenuated by a factor $\alpha$ and the side input signal (S),
- produces a right output signal for transmission to the right loudspeaker in said pair, which is equivalent to the sum of the mid input signal (M) attenuated by the factor $\alpha$ and the side signal (S) phase shifted 180°.

29. An audio stereo signal reproduction system according to claim 28, **characterised in** that the attenuation factor $\alpha$ is in the range - 3 dB to −10 dB.

30. An audio stereo signal reproduction system according to claim 28, **characterised in** that the attenuation factor $\alpha$ is in the range −5 dB to −10 dB.

31. An audio stereo signal reproduction system according to claim 28, **characterised in** that the attenuation factor $\alpha$ is in the range −6 dB to −9 dB.

32. An audio stereo signal reproduction system according to any one of claims 28 - 31, **characterised in** that the attenuation factor $\alpha$ is frequency dependent.

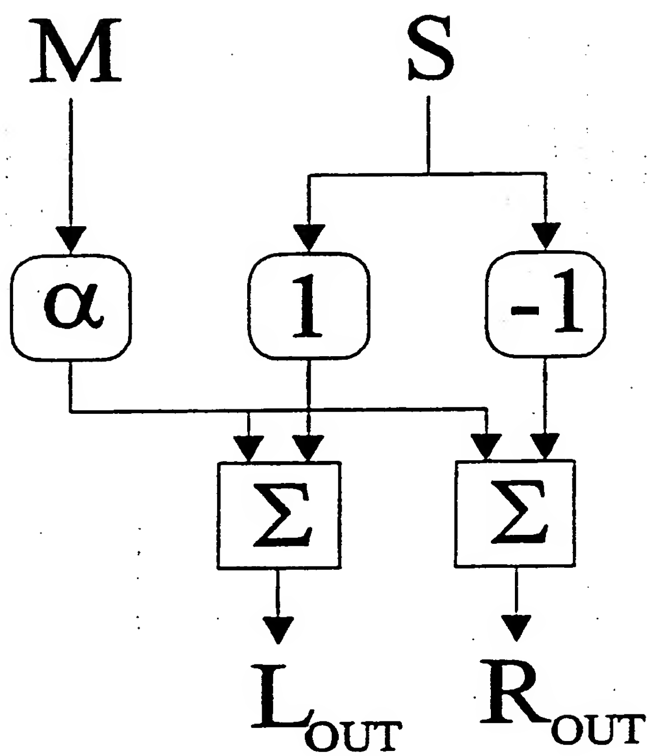


Fig. 1

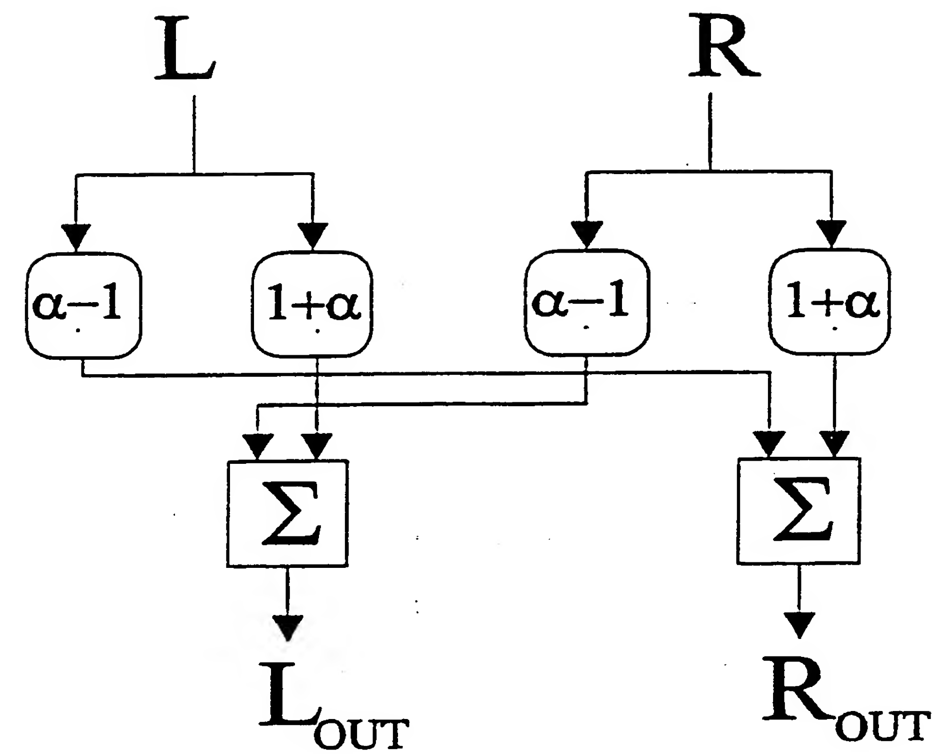


Fig. 2

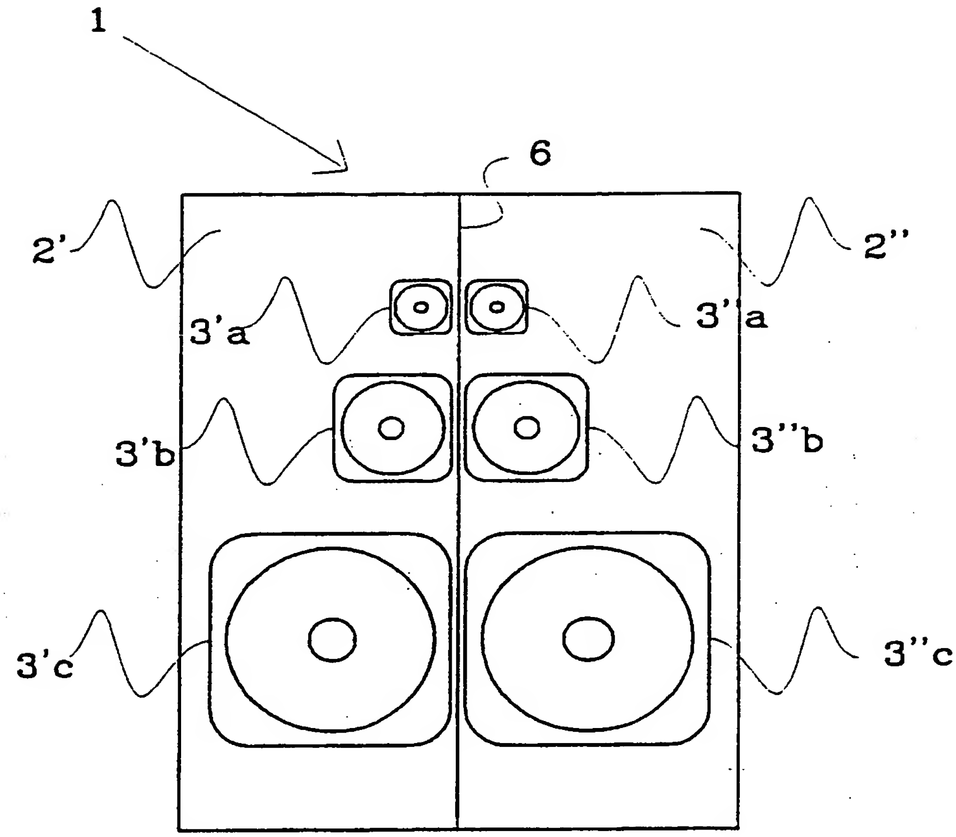


Fig. 3

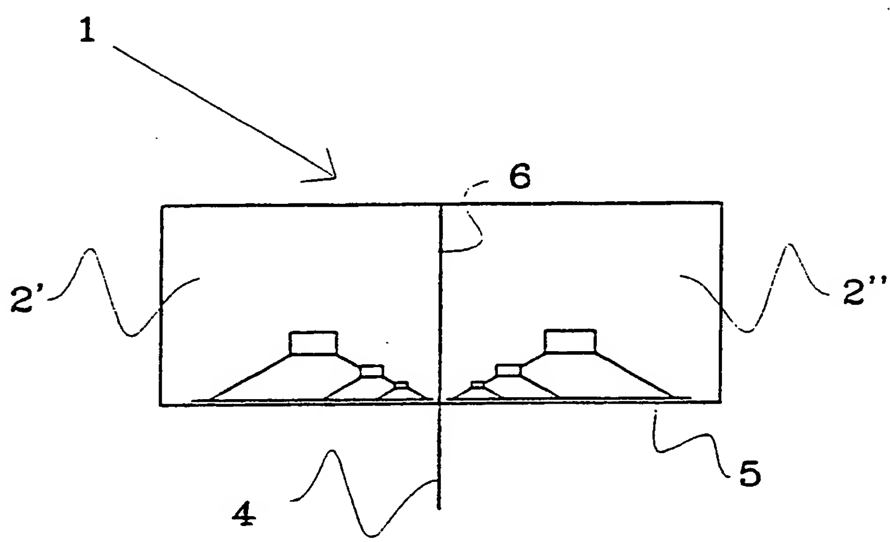


Fig. 4

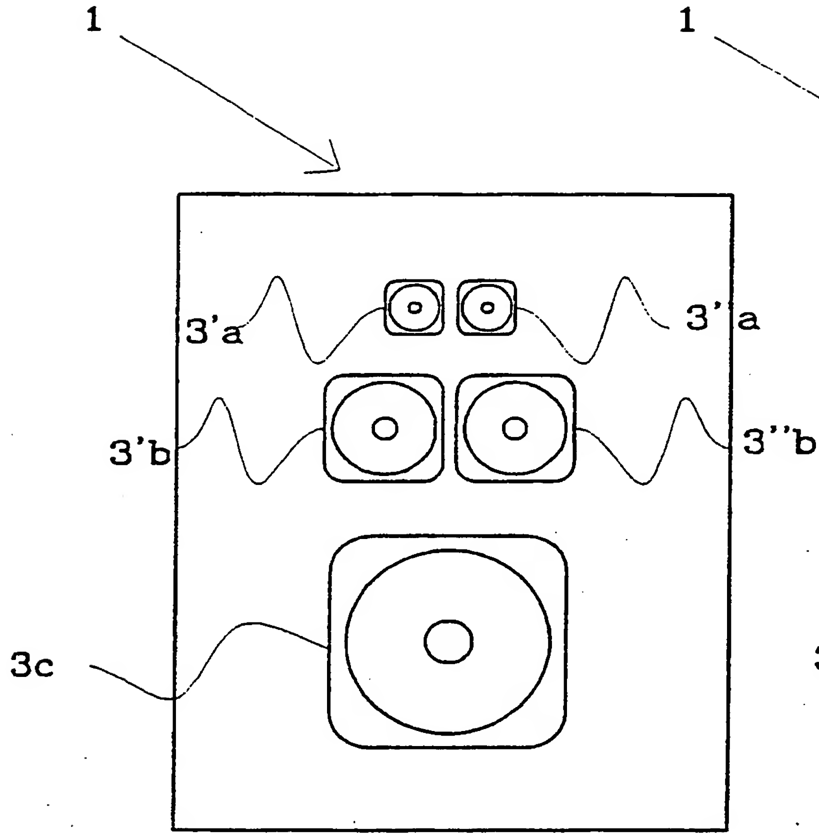


Fig. 5

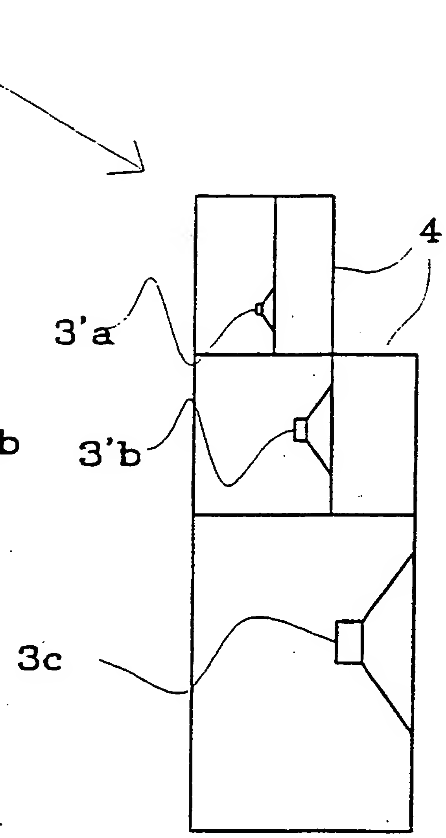


Fig. 7

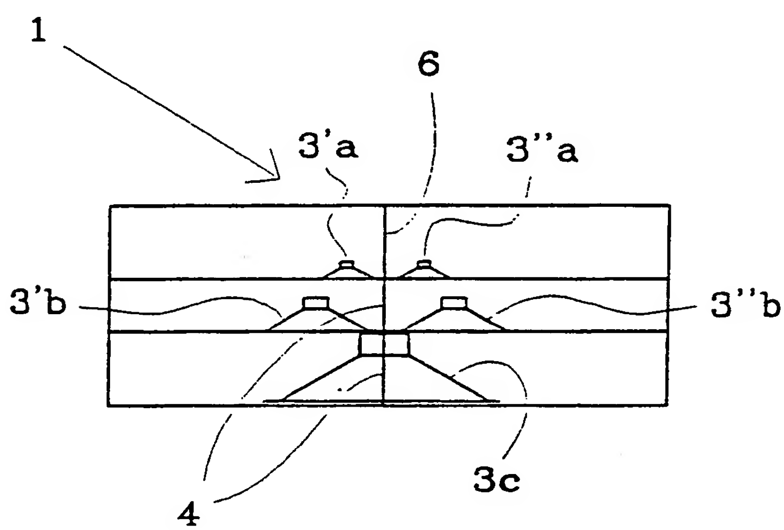


Fig. 6

# INTERNATIONAL SEARCH REPORT

Inten. .onal application No.
PCT/SE 00/01301

## A. CLASSIFICATION OF SUBJECT MATTER

IPC7: H04S 1/00

According to International Patent Classification (IPC) or to both national classification and IPC

## B. FIELDS SEARCHED

Minimum documentation searched (classification system followed by classification symbols)

IPC7: H04S

Documentation searched other than minimum documentation to the extent that such documents are included in the fields searched

SE,DK,FI,NO classes as above

Electronic data base consulted during the international search (name of data base and, where practicable, search terms used)

## C. DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | US 3892624 A (S. SHIMADA), 1 July 1975 (01.07.75), column 1, line 40 - column 2, line 5<br>-- | 1-20,25-32 |
| A | US 5553147 A (J.E.M. PINEAU), 3 Sept 1996 (03.09.96), column 4, line 45 - column 5, line 15; column 7, line 33 - line 36, figures 3,4<br>-- | 1-17,25-32 |
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| A | EP 0773702 A2 (SRS LABS, INC.), 14 May 1997 (14.05.97), difference and summing circuits (11, 13)<br>-- | 1-15,28-32 |

[X] Further documents are listed in the continuation of Box C.

[X] See patent family annex.

* Special categories of cited documents:

"A" document defining the general state of the art which is not considered to be of particular relevance

"E" earlier application or patent but published on or after the international filing date

"L" document which may throw doubts on priority claim(s) or which is cited to establish the publication date of another citation or other special reason (as specified)

"O" document referring to an oral disclosure, use, exhibition or other means

"P" document published prior to the international filing date but later than the priority date claimed

"T" later document published after the international filing date or priority date and not in conflict with the application but cited to understand the principle or theory underlying the invention

"X" document of particular relevance: the claimed invention cannot be considered novel or cannot be considered to involve an inventive step when the document is taken alone

"Y" document of particular relevance: the claimed invention cannot be considered to involve an inventive step when the document is combined with one or more other such documents, such combination being obvious to a person skilled in the art

"&" document member of the same patent family

| Date of the actual completion of the international search | Date of mailing of the international search report |
|---|---|
| 18 January 2001 | 22-01-2001 |
| Name and mailing address of the ISA/<br>Swedish Patent Office<br>Box 5055, S-102 42 STOCKHOLM<br>Facsimile No. +46 8 666 02 86 | Authorized officer<br><br>Leif Vingård / JA A<br>Telephone No. +46 8 782 25 00 |

# INTERNATIONAL SEARCH REPORT

| International application No. |
|---|
| PCT/SE 00/01301 |

C (Continuation). DOCUMENTS CONSIDERED TO BE RELEVANT

| Category* | Citation of document, with indication, where appropriate, of the relevant passages | Relevant to claim No. |
|---|---|---|
| A | WO 9730566 A1 (ADAPTIVE AUDIO LIMITED), 21 August 1997 (21.08.97), page 2, line 18 - line 24, fig. 1b (virtual sources vs. real sources), fig. 2 (closely-spaced pair of loudspeakers)<br>-- | 1-20,25-32 |
| A | US 4394537 A (SHIMA ET AL), 19 July 1983 (19.07.83), a means for improved stereo separation using a varying difference signal, addition means, phase inverters and more<br>-- | 1-15,28-32 |
| A | US 4596034 A (MONCRIEFF), 17 June 1986 (17.06.86), optional baffle boards 30a-30c<br>--<br>-------- | 16,17,20-22, 24 |

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE00/01301

One invention according to claims 1, 9 and 16 and related claims, and one invention according to claims 3 and 11 and related claims.

Claim 1 refers to a method of producing a specific pair of left and right output signals from one kind (M+S) of input signals. Claim 3 refers to a method of producing a similar type of left and right output signals, but from another kind (L+R) of input signals. As similar left and right output signals are to be produced from different input signals with the two methods, said two methods require different processing. As the two claimed processes do not comprise any common or corresponding special technical features over prior art, they are not so linked as to form a single general inventive concept (PCT Rule 13.1 and 13.2).

# INTERNATIONAL SEARCH REPORT

International application No.
PCT/SE00/01301

**Box I** **Observations where certain claims were found unsearchable (Continuation of item 1 of first sheet)**

This international search report has not been established in respect of certain claims under Article 17(2)(a) for the following reasons:

1. ☐ Claims Nos.:
because they relate to subject matter not required to be searched by this Authority, namely:

2. ☐ Claims Nos.:
because they relate to parts of the international application that do not comply with the prescribed requirements to such an extent that no meaningful international search can be carried out, specifically:

3. ☐ Claims Nos.:
because they are dependent claims and are not drafted in accordance with the second and third sentences of Rule 6.4(a).

**Box II** **Observations where unity of invention is lacking (Continuation of item 2 of first sheet)**

This International Searching Authority found multiple inventions in this international application, as follows:

.../...

1. ☒ As all required additional search fees were timely paid by the applicant, this international search report covers all searchable claims.

2. ☐ As all searchable claims could be searched without effort justifying an additional fee, this Authority did not invite payment of any additional fee.

3. ☐ As only some of the required additional search fees were timely paid by the applicant, this international search report covers only those claims for which fees were paid, specifically claims Nos.:

4. ☐ No required additional search fees were timely paid by the applicant. Consequently, this international search report is restricted to the invention first mentioned in the claims; it is covered by claims Nos.:

**Remark on Protest**

☒ The additional search fees were accompanied by the applicant's protest.

☐ No protest accompanied the payment of additional search fees.

# INTERNATIONAL SEARCH REPORT

Information on patent family members

27/12/00

International application No.
PCT/SE 00/01301

| Patent document cited in search report | Publication date | Patent family member(s) | Publication date |
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